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WHITE

JOURNAL

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ELISHA MITCHELL SCIENTIFIC SOCIETY.

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VOL. XXI MARCH, 1905 NO. 1

A DESCRIPTIVE CATALOGUE OF THE MAMMALS OF NORTH CAROLINA, EXCLUSIVE OF THE CETACEA.

BY C. S. BRIMLEY.

This list is intended to represent our present knowledge of the occurrence and distribution of the land Mammals found within the limits of the State of North Carolina, together with keys to the orders, families and genera, and brief descriptions of the various species.

The keys are mainly adapted from Mr. G. S. Miller's "Key to the Land Mammals of Northeastern North America," but some use has also been made of Dr. Jordan's well known "Manual of the Vertebrates."

The material on which this list is based is as follows:

I. COLLECTIONS OF MAMMALS MADE IN NORTH CAROLINA.

1. A collection of the smaller mammals of Bertie county made for the author and his brother by Mr. T. A. Smithwick, of Walke, and Mr. J. W. P. Smithwick, of Sans Souci, in 1892, 1893, and 1894. The collection comprised nineteen species, the largest being the Flying Squirrel and a list of them was published by the author in the *American Naturalist*, March, 1897.

2. Specimens received from Mr. J. S. Cairns (now deceased),

of Weaverville, Buncombe county, comprising sixteen species of the smaller mammals of that region, the largest being the Red Squirrel. A Starnosed Mole was also received from Mrs. Cairns after her husband's death. (Collecting was done from about 1891 to 1894.)

3. In 1872 Dr. Elliott Coues collected a number of natural history specimens near Fort Macon and published notes on them, eighteen species mainly of the larger mammals being observed.

4. In 1897 Mr. R. T. Young collected small mammals in Currituck and Perquimans counties. The results of his collecting were published by Mr. S. N. Rhoads.

5. Collection from Roan Mt. in 1897 made by Mr. S. N. Rhoads.

6. Collections from Roan Mt. in 1887, 1892, 1893 and 1894 made by and for the United States Biological Survey.

7. Skulls and skins of a number of furbearing mammals trapped by Mr. Walton E. Stone from 1897 to 1900 in the neighborhood of Rosebay, Hyde county.

8. From about 1888 to 1900 my brother and myself collected small mammals near Raleigh, in Wake county, a list of which was published in the *American Naturalist*, May 1897.

9. Specimens received by the State Museum at Raleigh from various parts of the State. These have been mainly of the larger species.

II. RECORDS OF NORTH CAROLINA MAMMALS.

Records of North Carolina mammals scattered through the papers of American Mammalogists. (A list of all papers consulted by the author will be found at the end of the catalogue.)

III. LISTS OF THE LARGER AND BETTER KNOWN MAMMALS.

Lists of the larger and better known mammals of their vicinity received from Messrs. J. H. Armfield, Guilford county;

R. W. Collett, Cherokee county; R. D. Foxhall, Edgecombe county; N. W. Fain, Buncombe county; K. E. Shore, Forsyth county; T. A. Smithwick, Bertie county; Dr. J. W. P. Smithwick, Lenoir county; Miss Maggie Wicker, Moore county; and Dr. Donald Wilson, Cherokee county, to all of whom I am very much indebted for the information furnished.

Thanks are also due to Messrs. H. H. Brimley, Curator State Museum, Raleigh, N. C.; Dr. Witmer Stone, Academy of Natural Sciences, Philadelphia; G. S. Miller, Jr., United States National Museum; S. N. Rhoads, Philadelphia; Dr. J. A. Allen, American Museum of Natural History, New York; Outram Bangs, Boston, Mass.; and especially to Dr. C. Hart Merriam, Chief of the United States Biological Survey, for information given and assistance rendered.

The class Mammalia comprises warm blooded vertebrates, usually clothed with hair and never with feathers. A number of other characteristics define the class, but the warm blood distinguishes it from all other classes of animals except the birds and these are distinguished from mammals by the presence of feathers.

In the following catalogue the orders and families are arranged in the same sequence as in *Jordan's Manual.

Sixty-six species and subspecies are credited herein to North Carolina, and are numbered serially from 1 to 66. Nine other species, not yet known to occur are added in brackets without numbers, in their proper places. Some of the forms included may be really the same as other allied forms also included, or but slightly different, but I have tried to use as good judgment as was possible in the matter.

KEY TO THE ORDERS OF LAND MAMMALS OCCURRING IN NORTH CAROLINA.

a. Female generally (always in our species) provided with a pouch in which the young are carried for a time

*Manual of the Vertebrates of the Northern United States, by D. S. Jordan, Chicago, 1890, A. C. McClurg & Co.

after birth. Order I. Marsupialia. (Opossums, etc.)

aa. Females without external pouch for carrying the young.

b. Fore limbs modified to serve as wings. Order II. Cheiroptera (Bats).

bb. Fore limbs not modified to serve as wings.

c. Toes provided with hoofs. Order III. Ungulata. (Deer, Cattle, etc.)

cc. Toes not furnished with hoofs, but with claws of some sort.

d. Front teeth chisel shaped and separated from jaw teeth by a wide space. Order IV. Glires. (Squirrels, Rats, Mice, Rabbits, etc.)

dd. Front teeth not chisel shaped, tooth row nearly or quite continuous.

e. Brain large, well developed. In our species size large, eyes well developed, muzzle not greatly elongated. Order V. Ferae. (The flesh eaters, Cats, Dogs, Foxes, Bears, etc.)

ee. Brain small, not highly developed. In our species size small, eyes small or rudimentary, muzzle elongate. Order VI. Insectivora. (Moles and Shrews.)

ORDER I. MARSUPIALIA.

FAMILY DIDELPHIDAE (THE OPOSSUMS).

The members of this family, which is the only one represented in America, have 50 teeth, a prehensile tail, and the hind feet with five toes each, the outer one of which is clawless and thumb-like. Our only genus is,

GENUS DIDELPHIS, L.

1. *Didelphis virginiana*, Kerr. Common Opossum. Blackish

varied with grayish white, ears naked, leathery. *L. 28. T. 11. The Opossum is found throughout the whole State even in the most thickly settled portions.

ORDER II. GLIRES.

(THE RODENTS OR GNAWERS.)

Front teeth long, chisel-shaped; cheek teeth broad, short, flat-crowned, a wide toothless space between the front teeth and cheek teeth.

Five of the American families of this group are found in North Carolina, and may be distinguished as follows:

FAMILIES OF GLIRES.

a. Upper front teeth four, the second pair small and placed directly behind the first pair. Family Leporidae. (Hares and Rabbits.)

aa. Upper front teeth two.

b. Tail very broad, flattened from above downwards. Family Castoridae. (Beavers.)

bb. Tail round or flattened from side to side.

c. At least four well developed grinding teeth on each side in each jaw. Tail bushy. Family Sciuridae. (Squirrels.)

cc. Never more than three well developed grinding teeth in each jaw, tail close haired or nearly naked.

d. Hind feet not greatly elongated. Family Muridae. (Rats and Mice.)

dd. Hind feet and tail greatly elongated. Family Dipodidae. (Jumping Mice.)

*L=total length of animal from tip of nose to end of tail bone (not to end of hairs on end of tail).

T=length of tail from root to end of vertebrae (not to end of hairs). Measurements are in inches.

FAMILY LEPORIDAE. (THE RABBITS.)

Upper front teeth four, the second pair small and placed directly behind the others, which are grooved in front, teeth 28 in all. Tail short, recurved, eyes large, ears long, soles furred. The family includes the single genus Lepus, two species of which are found in North Carolina.

GENUS LEPUS, L.

a. *Post orbital process fused with the skull* (*subgenus Limnilagus*).

2. *L. palustris*, Bachm. Marsh Rabbit. Yellowish brown: tail very short, ashy not white, below. L. 17. T. 1. Ear 2½. Found in the marshes of the eastern part of the State, extending as far north as Hyde county and as far east as Lenoir county.

aa. *Post orbital processes not fused with the skull, but touching it behind enclosing a foramen* (*subgenus Sylvilagus.*)

3. *L. floridanus mallurus* Thomas. Cottontail Rabbit. Much grayer than the preceding, the tail twice as long, cottony white below. L. 18. T. 2. Ear 2⅓, hind foot 3¾. Common throughout the whole State.

(The Southern Varying Hare, *Lepus americanus virginianus* Harlan, a member of a third subgenus Lepus, which has the post orbital processes free behind, occurs in the Alleghanies as far south as Virginia. This is rusty brown above, the tail dull yellowish or whiti h below. L. 19. T. 2. Ear 3. Hind foot 5½.)

FAMILY DIPODIDAE (JERBOAS AND JUMPING MICE).

Front teeth two in each jaw, in our species grooved in front, cheek teeth usually four on each side in upper jaw (three in one species). There is only one American genus, two species of which occur in the State.

GENUS ZAPUS, COUES.

a. *A small, probably useless, tooth in front of first well developed grinder in upper jaw. Teeth 18 in number. Tail in our species brown to the extreme tip (subgenus Zapus).*

4. *Z. hudsonius americanus* Barton. Southern Jumping Mouse. Back dusky brown faintly tinged with reddish buff, sides reddish buff very slightly grizzled; under parts white tinged with yellowish. L. 7½. T. 4½. Hind foot 1⅛. Only known in this State from Wake county (Raleigh), the most southern locality it has been recorded from.

5. *Z. hudsonius hudsonius* Zimmermann. Northern Jumping Mouse. Back yellowish brown; sides light grayish buff, slightly sprinkled with black, belly white tinged with yellowish. L. 8½. T. 5⅛. Hind foot 1 3-16. Known only in this State from Roan Mt., the most southern locality from which it is known.

aa. *No small tooth in front of first well developed grinder in upper jaw, teeth 16; tail more or less tipped with white (subgenus Napaeozapus).*

6. *Z. insignis roanensis* Preble. Roan Mt. Jumping Mouse. Sides bright tawny ochraceous; back much darker. Under parts pure white. Tail more or less tipped with white. L. 8¾. T. 5⅜. Hind foot 1 3-16. Known only from the evergreen forests of Roan Mt.

FAMILY MURIDAE.

Front teeth two, cheek teeth never more than three in each jaw. In the species that occur within our limits the hind feet and legs are never greatly elongated for jumping. Ten of the numerous genera occur in the State, one genus with its three or four species being an introduction from the old world, the remaining nine genera are all natives.

a. Grinding teeth with tubercles arranged in three transverse rows, very distinct in teeth of upper jaw (subfam. Murinae, Old World Rats and Mice). GENUS MUS,

aa. Grinding teeth with tubercles in two rows or without distinct tubercles of any kind.

b. Crowns of grinding teeth with tubercles in two rows.

bb. Crowns of grinding teeth divided into loops or triangles, (subfam. Cricetinae, American Rats and Mice).

c. Upper front teeth grooved, size small.
GENUS REITHRODONTOMYS.

cc. Upper front teeth not grooved.

d. Tail as long as or longer than head and body, total length of adults 9 inches or over, fur coarse.
GENUS ORYZOMYS.

dd. Tail much shorter than head and body, total length of adults 9½ inches or over, form stout, fur coarse. GENUS SIGMODON.

ddd. Total length of adults under 8 inches, fur fine and soft, belly white. Tail as long as head and body or somewhat shorter. GENUS PEROMYSCUS.

e. Upper front teeth narrow, compressed; tail always eyes and ears large, belly white, (subfam. Neotominae, Wood Rats and Cave Rats).
GENUS NEOTOMA.

ee. Upper front teeth broad; tail usually short; ears and eyes small; belly generally not white (subfam. Microtinae, Voles and Lemmings).

f. Lower front teeth short, their roots terminating on inner side of grinders (upper front teeth grooved in our species).
GENUS SYNAPTOMYS.

ff. Lower front teeth long, their roots extending under posterior grinding teeth into outer side of jaw.

g. Tail flattened sideways, size large. GENUS FIBER.

gg. Tail round, size small or medium.

h. Grinding teeth without roots (prongs).
GENUS MICROTUS.

hh. Grinding teeth with roots (prongs) in adults.
GENUS EVOTOMYS.

GENUS MUS, L. (Introduced Rats and Mice).

7. *Mus musculus* L. House Mouse. Brownish gray, paler below. L. 6¾. T. 3⅜. Very common in houses and largely so in fields also.

8. *M. alexandrinus* Geoff, St. Hil. Roof Rat. Brown, under parts white. Tail as long or longer than head and body; about size of *Mus rattus*. Common at Raleigh and probably the common house rat of the whole State.

(*M. rattus* L. Black Rat. Blue-black darker on the back, more slaty on the belly. L. 15¼. T. 8½. Tail as in the Roof Rat about as long as head and body. The Black Rat was formerly wide spread in the eastern United States, but has been in the north almost exterminated by the Brown Rat. It very probably occurs or has occurred in the past, but we have no records.)

9. *M. norvegicus* Erxl. Brown Rat, Wharf Rat. Brownish above, grayish below, tail shorter than head and body. L. 15¾. T. 7⅛. The common house rat of the north as *M. alexandrinus* is of the south, but the only record we have for North Carolina is that of Coues, who says they were common in the vicinity of Fort Macon in 1870.

GENUS SIGMODON (Cotton Rats).

10. *S. hispidus* Say & Ord. Cotton Rat. Upper parts brown coarsely and irregularly varied with brownish black, brownish white below. Form short and stout. L. 10½. T. 4. Only recorded in this State from Raleigh, where it is abundant, but undoubtedly occurs commonly throughout the greater part of eastern North Carolina.

GENUS REITHRODONTOMYS, GIGLIOLI (Harvest Mice).

11. *Reithrodontomys lecontei lecontei* Aud & Bach. Harvest Mouse. Light brown above, whitish beneath. L. 5. T. 2⅜. Much like a House Mouse but smaller and distinguished by its grooved front teeth and furry ears. Has only been taken

in Wake and Bertie counties, where it is common, but doubtless occurs throughout the greater part of the State.

(*Reithrodontomys lecontei impiger* Bangs. Virginia Harvest Mouse. Russet brown above, dull white below. L. 4½. T. 2. Common at White Sulphur Springs, West Virginia, and therefore probably occurs in the northeastern part of the State but seems scarcely distinct from the preceding.)

GENUS PEROMYSCUS, GLOGER (Deer Mice).

12. *P. leucopus* Raf. Deer Mouse. Tail 40 to 45 per cent. of total length. Chestnut brown above, pure white below sharply defined against the color of the sides, tail bicolor. Young bluish gray. L. 6½. T. 3. Hind foot 1 3-16. Common in Wake, Bertie, Buncombe, Perquimans and Currituck counties, and probably throughout the whole State.

13. *P. canadensis nubiterrae* Rhoads. Cloudland Deer Mouse. Dull brownish above, white below, the two colors sharply defined; tail as long as head and body with a tuft of hairs at tip. L. 6½. T. 3½. Only known from Roan Mt. in Mitchell county.

14. *P. gossypinus* Leconte. Cotton Mouse. Dark brown above with broad darker dorsal band, under parts gray, feet and hands grayish white. Young blackish slate gray above, slate gray beneath. L. 7. T. 2⅞. This species replaces its smaller relative (*P. leucopus*) in the southeastern United States and in this State most probably occurs throughout the whole southeastern portion but is so far only known to occur in Bertie and Currituck counties.

15. *P. nuttali* Harlan. Golden Mouse. Golden cinnamon above, yellowish white beneath passing gradually on the sides into the color of the back. Tail unicolor. Young similar to the adults in color. L. 6. T. 2½. An arboreal species building its nest 6 to 12 feet high in reeds or bushes in lowland thickets. Probably common throughout most of the State, as it has been taken in Bertie, Wake, Halifax, Perquimans, and Buncombe counties.

GENUS ORYZOMYS, BAIRD (Marsh Rats).

16. *O. palustris* Harlan. Ricefield Rat. Dark brown above, whitish below, ears short, furry, tail about as long as head and body, hind feet large. L. 9½. T. 4¾. A semi-aquatic species inhabiting cattail swamps and marshes from Florida to New Jersey. In this State it has only been taken in Wake county (Raleigh), where it is not uncommon in suitable situations.

GENUS NEOTOMA, SAY & ORD (Wood Rats.)

17. *N. pennsylvanica* Stone. Alleghany Cave Rat. Grayish above, white below. Tail sharply bicolor. L. 16¼. T. 7⅜. Common in caves and rocky woods throughout the Alleghanies. Only known in this State from Roan Mt., Mitchell county.

(*N. floridiana* Ord. Wood Rat. Brownish gray above, the sides more yellowish, white below, tail furry, bicolor. L. 16. T. 7½. I have had nests described to me by colored men, who said they had seen them many years ago in the eastern part of the State, which might have belonged to this species. So far as I know, however, it is not known to occur nearer here than southern Georgia.)

GENUS SYNAPTOMYS, BAIRD.

18. *S. cooperi* Baird. Cooper's Lemming. Color grizzled gray and yellowish brown above, thickly sprinkled with black; dirty white below. L. 4⅞. T. ¾. Only known in this State from Roan Mt., Mitchell county, and Chapanoke, Perquimans county. Inhabits sphagnum bogs.

GENUS FIBER, CUVIER (Muskrats).

19. *F. zibethicus* L. Muskrat. Color brown, much suffused with yellowish and reddish (or black above and below, or black above and paler below than in the common form). L. 24. T. 10½. Common along streams throughout the State.

The black form with pale belly is not uncommon at Raleigh, and we have also had it from Hyde county. The all black form we have only seen from Hyde county.

20. *F. macrodon*, Merriam. Dismal Swamp Muskrat. "Color very much darker and teeth very much larger, otherwise as in *F. zibethicus*" (Jordan's Manual) described from Dismal Swamp, Virginia, but undoubtedly has no respect for State lines.

GENUS MICROTUS, SCHRANK (Meadow Mice or Voles).

21. *M. pennsylvanicus pennsylvanicus* Ord. Meadow Mice. Upper parts dark brown, much sprinkled with black, under parts gray. L. 6¾. T. 2. Common at Raleigh and in Mitchell and Buncombe counties. The common mouse of wet meadows, but occurring sparingly on the uplands. Not known south of North Carolina, except in the mountains.

22. *M. pennsylvanicus nigrans* Rhoads. Albemarle Meadow Mouse. Above dark brownish slate black, dark brown on sides, under parts dark brown. L. 7. T. 2. Only known from Currituck, Currituck county, the type locality.

23. *M. pinetorum pinetorum* LeConte. Pine Mouse. Fur dense velvety and mole like, eyes and ears very small, claws on forefeet longest. Color above chestnut, ashy below, young slaty. L. 5. T. ⅞. Common at Raleigh and in Bertie and Currituck counties, and probably throughout the State. This species digs burrows of its own or follows the mole runs under ground, feeding on such crops as peanuts, sweet potatoes and Irish potatoes without the damage being evident till the crop is dug.

24. *M. pinetorum scalopsoides* Aud & Bach. Northern Pine Mouse. Adults reddish brown, lighter than in *pinetorum*. One specimen from Magnetic City, Mitchell county, and two from Currituck referred to this form by Bailey (*N. A. Fauna, No. 17, 1900*).

GENUS EVOTOMYS, COUES.

25. *E. carolinensis* Merriam. Carolina Redbacked Mouse.

Ears large, projecting conspicuously above the fur, back dark chestnut fading insensibly into the brown of the sides. L. 5⅞. T. 1¾. Probably found on the higher summits of the mountainous region of the State, but so far recorded only from Macon and Mitchell counties.

FAMILY CASTORIDAE (THE BEAVERS).

Large, clumsily built, aquatic rodents with four broad, rootless cheek teeth in each side of each jaw. Tail very broad and scaly, flattened from above, downward.

GENUS CASTOR, L.

26. *C. canadensis carolinensis* Rhoads. Carolinian Beaver. Scaly portion of tail less than twice as long as wide, fur relatively short and harsh. L. 35. In this State the beaver occurs sparingly on the Dan River in Stokes county (the type locality of the subspecies) and is also reported from Bertie county. A specimen taken some fifteen or twenty years ago at Weldon is in the State Museum at Raleigh. These localities are all on the Roanoke River or its tributaries. Mr. J. H. Armfield reports a few occurring in Beaver Swamp in the northern part of Guilford county and southern part of Rockingham, and Mr. K. E. Shore reports them from the Yadkin River, between Yadkin and Forsyth counties.

FAMILY SCIURIDAE (THE SQUIRRELS).

Upper front teeth two; upper cheek teeth four or five on each side; lower cheek teeth four on each side. A well developed bony process on skull above and behind eye socket (postorbital process); tail round covered with long hairs which are usually so arranged as to form a broad flat brush. Four of the North American genera occur in the State.

a. Sides with a densely furred membrane joining front and hind legs (Flying Squirrels)....GENUS SCIUROPTERUS.
aa. Sides without membrane.

b. Form stout and clumsy; tail less than half as long as body; skull nearly flat on top (Woodchucks).
GENUS ARCTOMYS.

bb. Form slender and graceful; tail much more than half as long as body; top of skull distinctly rounded.

c. Cheek pouches present; back striped (Chipmunks).
GENUS TAMIAS.

cc. Cheek pouches absent; back not striped (Squirrels).
GENUS SCIURUS.

GENUS SCIURUS, L. (Squirrels).

27. *S. hudsonius loquax* Bangs. Southern Red Squirrel, Mountain Boomer. Back red, under parts white, edge of tail yellowish. L. 12½. T. 5⅛. (The length of tail does not include the distance the hairs project beyond the flesh but is the length of the tail vertebrae only. This is important to note in the case of the Squirrels and other mammals with hairy tails.) The Mountain Boomer is found throughout the mountains of the State from Cherokee to the Virginia line.

28. *S. carolinensis* Gmelin. Southern Gray Squirrel. Size medium, back dark yellowish rusty-gray. L. 18. T. 8. Common throughout the whole State.

29. *S. niger* L. Southern Fox Squirrel. Largest of the eastern Squirrels. Color very variable, gray, rusty or black, but the ears and nose are always white. Feet and hands very large, fur coarse and harsh. L. 25. T. 12. Said by Bangs to be wholly confined to the great pine forest of the South Atlantic and Gulf States. Only known in this State from Tarboro and Craven county. Specimens from the latter county are in the State Museum.

(*S. ludovicianus* Gray. Northern Fox Squirrel. Back mixed black and rusty, belly varying from pale rust color to rusty white; ears rusty (never white but the nose is sometimes white). L. 23. T. 10½. Fox Squirrels are recorded from the neighborhood of Asheville by Mr. N. W. Fain, and from Cherokee county by Dr. Donald Wilson and may be this species or the preceding. Dr. Wilson sent me a skin without

the skull from his county which I sent to Mr. Outram Bangs for determination, and he wrote me as follows: "About the squirrel I am puzzled. If I had the skull I could be sure. It looks to me, however, like *neglectus* rather than *niger*. There is a great difference in size between them, and this skin seems small, but of course I cannot tell how old it is. The color is variable in both species, but as you say, the ears in your skin are not white enough. Although a very unsatisfactory identification, I think I should call it *Sciurus ludovicianus neglectus*. I should hate, however, to publish this as positive proof one way or the other, without seeing the skull."

GENUS TAMIAS, ILLIGER (Chipmunks).

30. *T. striatus* L. Chipmunk. Reddish brown, back with five black stripes and two whitish ones. L. 11. T. 4½. The Chipmunk is found throughout the western half of the State extending as far east as the western edge of Raleigh township, in Wake county, and as far south as Cherokee in the mountains.

GENUS ARCTOMYS, SCHREBER (Woodchucks).

31. *A. monax* L. Woodchuck, Ground Hog. Grizzly gray, varied with chestnut, yellowish and blackish; under parts reddish. L. 18. T. 4½. Common throughout the mountainous region of the State.

GENUS SCIUROPTERUS, F. CUVIER (Flying Squirrels).

32. *S. volans* L. Flying Squirrel. Back drab, somewhat shaded with russet, belly pure white to extreme base of hairs. L. 9. T. 4. Common throughout the whole State.

ORDER III. INSECTIVORA.

Canine teeth present, but usually not conspicuously developed; cheek teeth formed for chopping; toes provided with

claws; brain small. (Our species are all small, under 8 inches in length, eyes and ears small or rudimentary, fur more or less molelike.)

Two families occur in North America and another in the West Indies, while no members of this group are known from South America except the extreme northwest corner only.

a. Forefeet highly modified for digging; external ear absent (Moles) FAMILY TALPIDAE.

aa. Forefeet not highly modified for digging; external ear present (Shrews) FAMILY SORICIDAE.

FAMILY TALPIDAE (THE MOLES).

Body thick and clumsy without distinct neck; eyes rudimentary or concealed; no external ear; front feet very large, the nearly circular palm held lengthwise; fur very soft and velvety.

a. Tip of muzzle with a fringe of fleshy projections; tail long; teeth 44. GENUS CONDYLURA.

aa. Tip of muzzle without a fringe of fleshy projections; tail short.

b. Teeth 36; tail slender and nearly naked. GENUS SCALOPS.

bb. Teeth 44; tail thick and very hairy. GENUS PARASCALOPS.

GENUS CONDYLURA, ILLIGER.

33. *C. cristata* L. Starnosed Mole. Dusky brown, paler and grayer below; tail nearly as long as head and body. L. 6¾. T. 2⅞. Known only in this State from Mitchell county, where it was taken at Magnetic City by the collectors of the Biological Survey of the United States Department of Agriculture in 1892 or 1893, and from Buncombe county, where a single specimen was taken by Mrs. J. S. Cairns, at Weaverville, February 6, 1896. It is said to inhabit wet places.

GENUS PARASCALOPS, TRUE.

34. *P. breweri* Bachm. Brewer's Mole. Dark lead gray,

seldom, if ever, tinged with rusty. Tail dark. L. 5 13-16. T. 1 3-16. Like the preceding, a northern species extending its range southward in the mountains. Said to inhabit dry soil. Known only in this State by the numerous specimens taken by the collectors of the United States Biological Survey in 1892 and 1893 at Magnetic City, in Mitchell county.

GENUS SCALOPS, ILLIGER.

35. *S. aquaticus* L. Common Mole. Light glossy slate brown, tinged with rusty; tail whitish. L. 6⅜. T. 1 1-16. The Common Mole is abundant throughout the State.

FAMILY SORICIDAE (THE SHREWS).

Body usually slender and mouse like with a distinct neck, eyes well developed but very small, a distinct external ear, front feet small, not mole like. Shrews are small animals, something like mice, but with pointed snouts and small eyes, the Mole Shrews of the genus Blarina have, however, a casual resemblance to little moles, except in the forefeet. Two genera occur in North Carolina.

a. Ears completely hidden by the fur, tail short. GENUS BLARINA.

aa. Ears distinctly visible, tail long. GENUS SOREX.

GENUS BLARINA GRAY.

a. *Teeth 32, total length 4 inches or over (subgenus Blarina).*

36. *B. brevicauda* Say. Mole Shrew. Color sooty slate brown above, more ashy below. L. 4¾. T. 1. Found throughout the mountains of the State from Cherokee to the Virginia line.

37. *B. carolinensis* Bachm. Carolina Shrew. Very similar to the preceding, but smaller and more slender, being only about 4 inches in total length. Occurs probably throughout the State except in the mountains, but has only been taken in Wake (Raleigh, Apex) and Perquimans counties (Chapanoke).

38. *B. telmalestes* Merr. Dismal Swamp Mole Shrew. About same size as *brevicauda*, but more plumbeous in color, and with a narrower skull. Taken by Dr. Merriam at Dismal Swamp, Virginia, and by Mr. R. T. Young, at Chapanoke, Perquimans county, and Currituck, Currituck county. The relationship of this and the two preceding forms to one another does not seem clear to me and hence I list them as full species "without prejudice."

aa. Teeth 30, in our species length about 3 inches.

39. *B. parva* Say. Little Mole Shrew. Color brownish above, ashy below. L. 3. T. 9-16. Its range in the State is probably about that of *B. carolinensis*, but it is at present only recorded from Wake and Bertie counties.

GENUS SOREX, L.

(a. *Total length over 5½ inches; hind feet conspicuously fringed* (*subgenus Neosorex*). *S. albibarbis* Cope. Eastern Marsh Shrew. Upper parts blackish slate with a slight hoary cast; chin and throat grayish white, rest lower parts of dusky. L. 6⅛. T. 2¾. The Marsh Shrew inhabits marshes and the borders of streams, south in the mountains to Pennsylvania and probably further.)

aa. *Total length under 5 inches, hind feet not fringed* (*subgeuus Sorex*).

40. *S. fumeus* Miller. Smoky Shrew. Smoky slate color, slightly paler below. L. 4⅛. T. 1¾.

41. *S. personatus* Geoff St. Hil. Masked Shrew. Upper parts dark brown, under parts whitish gray. L. 4⅛. T. 1 9-16. This and the preceding have both been taken by the collectors of the United States Biological Survey on Roan Mt., Mitchell county, in 1892.

42. *S. longirostris* Bach. Southern Shrew. Smallest of the eastern shrews. Chestnut brown above, ashy tinged with drab below. L. 3⅜. T. 1¼. Rare at Raleigh and one specimen known from Bertie county. The limits of the range

of this species are unknown, the above specimens being the only ones known to have been taken anywhere, since the species was described by Bachman from specimens taken in the swamps of the Santee River, South Carolina.

43. *S. fisheri*, Merr. Dismal Swamp Shrew. Similar to the preceding, but larger and coloration duller. L. 4⅛. T. 1½. This and the preceding have the third unicuspid tooth decidedly smaller than the fourth, whereas in *S. fumeus* and *S. personatus* the reverse is the case. Described by Dr. Merriam from Dismal Swamp, Virginia, and taken by Mr. R. T. Young at Chapanoke, Perquimans county.

ORDER IV. CHEIROPTERA. (BATS.)

Forelimbs greatly developed, the elongated fingers supporting a membrane by means of which true flight is performed.

a. Tail included in the flying membrane nearly or quite to tip, nose without leaf-like fleshy growths.
FAMILY VESPERTILIONIDAE.

aa. Tail in our species free from the membrane for its apical half. FAMILY EMBALLONURIDAE.
(One species of the Emballonuridae, *Nyctinomus cynocephalus* Lec. The Florida House Bat, a small brown bat with tail projecting for about half its length beyond the membrane and with naked wings is common in Florida and the Gulf States and may possibly occasionally straggle as far north as this State.)

FAMILY VESPERTILIONDAE. (The Typical Bats.)

a. Nostrils simple, at tip of snout; ears moderate; forehead not grooved.
b. Upper front teeth four, membrane between legs not completely furred above.

c. Fur blackish, frosted with white.
GENUS LASIONYCTERIS.
cc. Fur not blackish, not frosted with white.
d. Total length over four inches, teeth 32.
GENUS VESPERTILIO.
dd. Total length under four inches.
e. Color dull brown; ears rather long; teeth 38.
GENUS MYOTIS.
ee. Color light yellowish brown, teeth 34.
GENUS PIPISTRELLUS.
bb. Upper front teeth two.
f. Membrane between hind legs completely furred above, ears short and round. GENUS LASIURUS.
ff. Membrane between hind legs not furred above.
GENUS NYCTICEIUS.
aa. Nostril margined behind by grooves; cheeks with large excrescences; ears very large, an inch high.
GENUS CORINORHINUS.

GENUS LASIURUS, GRAY.

44. *L. cineureus* Beauv. Hoary Bat. General color a mixture of light yellowish brown, deep umber brown, and white. L. 5½. T. 2. Spread of wing 14. Has been taken by Cairns in Buncombe county, and the Smithwicks in Bertie county and Coues records it as occasional in summer at Fort Macon.

45. *L. borealis* Muller. Red Bat. General color varying from rufus red to yellowish gray, a white spot at shoulder, sometimes connected with its fellow by a white chest band. L. 4¼. T. 2. Spread 12. Common in Wake, Bertie, Buncombe, and at Fort Macon, also at Magnetic City, and on Roan Mt., and probably throughout the State.

GENUS NYCTICEIUS, RAF.

46. *N. humeralis* Raf. Twilight Bat. Dull umber brown

above, paler below. Common in Bertie, Wake and Buncombe, and probably throughout the State. L. 3½. Spread 9.

GENUS MYOTIS, KAUP.

47. *M. subulatus* Say. Say's Bat. Dull brown, slightly paler and more yellowish below. Ear when laid forward reaching considerably beyond nose. L. 3⅜. Spread 9. A single specimen taken at Raleigh September 13, 1902, is referred by me to this species as it agrees with the foregoing characters.

48. *M. lucifugus* Lec. Little Brown Bat. Ear when laid forward barely reaching nostril, size and color as in *M. subulatus*. Mr. G. S. Miller, Jr., mentions a specimen from Mitchell county, and has identified a specimen from Buncombe county, kindly loaned me by Mr. W. E. Snyder, as this species, and Dr. Witmer Stone refers to it a specimen from Bertie county. Besides these, I have seen 6 from Buncombe, 2 from Bertie county, and 2 from Raleigh, which were either this or the preceding, but at the time we had them, the two species were confused, and I have been unable to locate the specimens and have them correctly placed.

GENUS LASIONYCTERIS, PETERS.

49. *L. noctivagans* Lec. Silver Black Bat. Blackish, frosted with white, membrane between hind legs furred to about the middle above. L. 4. Spread of wing 12. This bat apparently occurs all over the State, but does not seem to be common in any locality. Six specimens are recorded from Bertie county, a dozen or more from Wake, one from Buncombe, and one from Mitchell.

GENUS PIPISTRELLUS, KAUP.

50. *P. subflavus* F. Cuvier. Georgia Bat. General color light yellowish brown. L. 3⅜. Spread 9. This is the smallest of our bats and is common in Bertie, Buncombe and Wake, and probably throughout the State.

GENUS VESPERTILIO, L.

51. *V. fuscus* Beauv. Big Brown Bat. Brown, paler below. 4⅜. Spread 12. This species is known from Bertie, Wake and Buncombe, but is not common in either county.

GENUS CORINORHINUS, H. ALLEN.

52. *C. macrotis* Lec. Big Eared Bat. Blackish, fur soft and long. L. 3½. Spread 11. One taken by Cairns at Weaverville, Buncombe county, April 7, 1895, and three by the Smithwicks in Bertie county, February 1, 1893, and October 24, 1894, (two specimens) are the only records we have of this southern species. (Since the above was written the State Museum has received a specimen from Goldsboro.)

ORDER V. UNGULATA.

(THE HOOFED ANIMALS.)

Herbivorous mammals provided with one to four enlarged and thickened hoofs on each foot. The order contains mainly large species and includes such domestic animals as the horse, cow, hog, sheep, goat, etc.

Only one of the two groups of Ungulata, the Artiodactyla or even toed Ungulates, is represented in our fauna, and only two families of that.

Families of Ungulata now or formerly occurring in the State:

a. Horns solid, usually branching, present in our species only in the male (The Deer). FAMILY CERVIDAE.

aa. Horns permanent, hollow, each enclosing a bony core or process of the skull (The Cattle). FAMILY BOVIDAE.

FAMILY CERVIDAE (THE DEER).

Horns solid, shed every year; wanting in the female except

in the Reindeer. Only one species occurs in the State, but another doubtless did in earlier days.

a. Horns large, curved mostly backward, the tines all directed forwards, size large. GENUS CERVUS.

aa. Horns small, curved forward, the tines all directed upwards, size smaller. GENUS ODOCOILEUS.

GENUS CERVUS, L.

(*C. canadensis* Erxl. Eastern Wapiti, American Elk. Reddish brown, paler in winter; height at shoulders five feet; horns five feet long. Now extinct in the United States, but probably occurred in the western part of the State 150 years ago.)

GENUS ODOCOILEUS, RAF.

53. *O. virginianus* Bodd. Virginia Deer. Color in summer reddish, grayer in winter, under parts white. Not uncommon in the eastern section of the State and in the mountains, but rare or absent in the more thickly settled portions of the center.

FAMILY BOVIDAE. (THE CATTLE AND ANTELOPES.)

Only one genus, Bison, ever occurred east of the Mississippi, the cow, goat and sheep belong to this family.

GENUS BISON, H. SMITH.

(*B. bison* L. American Bison, Buffalo. The Buffalo was no doubt found in the western part of the State in early days.)

ORDER VI. FERAE.

(THE CARNIVORA OR FLESH EATERS.)

Canine teeth well developed, cheek teeth formed for cutting,

front teeth small in a row between the canines. Toes provided with claws. Brain large, well developed.

a. Limbs modified for swimming and useless for walking, hind feet not capable of being turned forward (The True Seals). FAMILY PHOCIDAE.

aa. Limbs fitted for walking.

b. Hind feet with 4 toes.

c. Claws capable of being withdrawn into a sheath, muzzle broad and short, teeth not more than 30 (The Cats). FAMILY FELIDAE.

cc. Claws blunt, not retractile, teeth 42 (Dogs, Wolves and Foxes). FAMILY CANIDAE.

bb. Hind feet with five toes.

d. Entire sole applied to the ground in walking.

e. Size large, tail rudimentary (The Bears). FAMILY URSIDAE.

ee. Size medium, tail well developed (Raccoons). FAMILY PROCYONIDAE.

dd. Entire sole not applied to the ground in walking (Weasels, Minks, Otters, Skunks, etc.). FAMILY MUSTELIDAE.

FAMILY PHOCIDAE. (THE SEALS.)

Only one genus and species occur on the coast.

GENUS PHOCA, L.

54. *P. vitulina* L. Harbor Seal. Grayish or brownish. L. five feet, female smaller. Occasional on our coast. A female in the State Museum from Craven county.

FAMILY PROCYONIDAE.

Plantigrade carnivora of small size with comparatively slender body and well developed tail. Teeth 40. Only one genus and species occur in the eastern United States.

GENUS PROCYON, STORR.

55. *P. lotor* L. Raccoon, Coon. Grayish, hairs black tipped with black rings, a black cheek patch. L. 33. T. 10½. The Raccoon is still found throughout the State, but is quite rare in the more thickly settled districts.

FAMILY URSIDAE (THE BEARS).

Plantigrade carnivora of large size, with rudimentary tail. Only one genus and species is known from the State.

GENUS URSUS, L.

56. *U. americanus* Pallas. Common American Bear, Hog Bear. Color blackish or brownish, variable. Still not uncommon in the swamps of the eastern and mountains of the western parts of the State, but not now found in the central portion.

FAMILY MUSTELIDAE (THE WEASELS).

Carnivora with the feet either plantigrade or digitigrade, the toes five on all four feet. Most species are provided with glands near the anus which secrete a bad smelling liquid. Teeth 32 to 38. Our species are usually of small or medium size.

a. Toes conspicuously webbed, snout short, high and blunt, teeth 36 (Otters). GENUS LUTRA.

aa. Toes not much webbed, snout longer, teeth 34.

b. Tail closely furred, claws short (Minks and Weasels). GENUS PUTORIUS.

bb. Tail bushy, claws long (Skunks).

c. Form stout and heavy. GENUS MEPHITIS.

cc. Form slender. GENUS SPILOGALE.

GENUS LUTRA, BRISSON.

57. *L. hudsonica* Desm. American Otter. L. 3½ feet. T. 16 inches. Color liver brown. Our form is *L. h. lataxina*

(F. Cuvier), with colors lighter than in the Northern Otter. The Otter is found throughout the State, but is apparently rarest in the mountains and most plentiful in the east.

GENUS PUTORIUS, CUVIER.

58. *P. vison lutreocephalus* Harlan. Carolina Mink. Color dark chestnut brown. L. 27. T. 8¼. The Mink is found commonly throughout the State, it being a semi-aquatic animal living mainly along watercourses.

59. *P. noveboracensis notius* Bangs. Southern Weasel. Brown above, yellowish white below, tail brown, black for posterior half. L. 16. T. 5½, the female much smaller, L. 12¾, T. 4¼. Rare in Wake (only two specimens seen in twenty years) and in Bertie, but rather common in Buncombe and Mitchell counties, and probably in the mountains generally. No Weasels are known in the eastern United States from south of Raleigh until we reach Florida.

GENUS MEPHITIS, CUVIER.

60. *M. elongata* Bangs. Large Southern Skunk. Polecat. Color black, a patch on the back of the head and two stripes extending back from it white. These stripes may be so greatly enlarged that the animal is nearly all white, or so greatly reduced that it is nearly all black. Tail very bushy with a white tip, the white on tail as variable in amount as that on body. L. 24. T. 9. Occurs only in the southern half of the State from the coast to the mountains. Very rare in Wake county, and not found in Bertie, Forsyth, Guilford, or other counties in the northern half of the State. The secretions of the anal glands (not urine, as is commonly supposed,) are so abundant and offensive in all skunks as to be the animal's chief weapon of offense.

GENUS SPILOGALE, GRAY.

61. *S. ringens* Merr. Little Striped Skunk. About the size and shape of a mink, color black with four narrow,

parallel, white stripes down the back, these breaking up on the rump into spots and transverse bars. Tail black with long, white pencil at tip. L. 18½. T. 7½. The Little Striped Skunk is found throughout the mountains where it seems to be commoner than the large skunk.

FAMILY CANIDAE (THE DOGS).

Carnivora that walk on the toes only, never on the sole of the foot; claws blunt; hind toes 4; teeth 42 in our species.

a. Upper front teeth distinctly lobed, pupil of eye circular (Dogs and Wolves). GENUS CANIS.

aa. Upper front teeth not lobed, pupil of eye elongate not circular.

b. Tail without mane of stiff hairs, and with abundant soft under fur (Red Foxes). GENUS VULPES.

bb. Tail with a concealed mane of stiff hairs and without soft fur (Gray Foxes). GENUS UROCYÓN.

GENUS CANIS, L.

62. *C. occidentalis* Rich. American Wolf. Back brownish or blackish mixed with tawny, belly light tawny or dirty whitish. Total length nearly five feet. Found sparingly throughout the mountains. Dr. Donald Wilson reports it from Graham county, Mr. R. W. Collett says it is growing very scarce in Cherokee, Mr. Fain says there are very few in Buncombe. Mr. H. H. Brimley, Curator of the State Museum, informs me it has been taken in recent years in Yancey, Caldwell and Watauga. Dr. Merriam states that in the year of one of his visits to Roan Mt. a den of wolves was discovered there and the young captured alive (in 1887 or 1892).

GENUS VULPES, RICHARDSON.

63. *V. fulvus* Desm. Red Fox. Reddish, feet and ears blackish, tip of tail white. L. 40. The commoner fox in the mountains and thence eastward along the northern border of

the State to Edgecombe (Foxhall). Not found in Bertie (Smithwick), Wake (Brimley), nor Forsyth (Shore).

GENUS UROCYON, BAIRD.

64. *U. cinereo-argenteus* Muller. Gray Fox. Back a coarse grizzle of blackish and white, belly and region about ears tawny. A black line along back of tail. L. 36. The Gray Fox is the common fox of the State except in the mountains where it is less common.

FAMILY FELIDAE (THE CATS).

Carnivora with short round head and retractile claws. Heel never applied to the ground in walking. Teeth 28 or 30.

a. Tail long, teeth 30, ears not tufted. GENUS FELIS.
aa. Tail short, teeth 28, ears tufted. GENUS LYNX.

GENUS FELIS, L.

65. *F. cougar* Kerr. American Panther, Puma. Yellowish brown above, middle line of back darker, under parts whitish. L. 8½ feet. T. 3 feet. A specimen killed near Rose Bay, Hyde, county, some years before the war between the States, according to Mr. Walton E. Stone, is the only authentic record from the State.

GENUS LYNX, KERR.

66. *L. rufus* Gueld. Wild Cat, Bay Lynx. Back yellowish gray tinged with rufous, much spotted and streaked with black, belly whitish spotted with black, a brownish collar on throat. L. 3 feet. T. 7 inches. Found in the wilder parts of the eastern and western portions of the State. Large specimens of this species are frequently called catamounts and supposed to be a different species, but in every case where the State Museum has endeavored to secure a "catamount," it has always proved to be this species and not the Canada Lynx, which does not occur in the State.

LIST OF PAPERS RELATING MORE OR LESS TO NORTH CAROLINA MAMMALS AND CONSULTED BY THE AUTHOR:

Allen, J. A., "Species of the Genus Reithrodontomys," Bull. A. M. N. H., Vol. XII., 1895, pp. 107 *et seq.* (Mentions *R. lecontei* from Raleigh, North Carolina, but gives its distribution erroneously, as "coast region of South Carolina and Georgia".)

Allen, J. A., "Revision of the Chickarees," Bull. Am. Mus. Nat. Hist., Vol. X., 1898, Article XIV. (Mentions *Sciurus hudsonius loquax* from North Carolina.)

Allen, J. A., "Five New North American Mammals," Bull. A. M. N. H., Vol. XII., 1899, page 13. (Mentions *Lepus floridanus mallurus* from Raleigh)

Bangs, O., "Three New Weasels From North America," Proc. New Eng. Zool. Club, Vol. I., pp. 53-57, June 9, 1899. (Describes as new *Putorius noveboracensis notius* from Weaverville and Raleigh, North Carolina.)

Bangs, O., "Notes on North American Mammals," Proc. Boston Soc. Nat. Hist. Vol. XXVI., July 31, 1895.

Bangs, O., "The Cotton Mouse (Peromyscus gossypinus)," Proc. Biol. Soc. Wash. Vol. X., pp. 119-125, Nov. 5, 1896. (Records specimens from Bertie county, North Carolina.)

Bangs, O., "A New Race of the Chickaree," Proc. New Eng. Zool. Club, March 31, 1899, Vol. I., pp. 27-29. (Contains references to the Red Squirrels or Chickarees, of Roan Mt., North Carolina.)

Bangs, O., "The Skunks of the Genus Mephitis of Eastern North America," Proc. Biol. Soc. Wash. Vol. X., pp. 139-144, Dec. 28, 1896. (Mentions the absence of skunks from parts of North Carolina.)

Bangs, O., "The Land Mammals of Peninsular Florida and the Coast Region of Georgia," Proc. Bost. Soc. Nat. Hist., Vol. 28, pp. 151-235, March, 1898. (Mentions a number of North Carolina mammals.)

Bangs, O., "A New Race of the Little Harvest Mouse From

West Virginia", Proc. Biol. Soc. Wash., Vol. XII., pp. 167-168, August 10, 1898. (This form may occur in North Carolina.)

Bangs, O., "Notes on the Synonymy of the North American Mink With Description of a New Subspecies", Proc. Bost. Soc. Nat. Hist., Vol. 27, pp. 1-6, March, 1896. (Contains references to Minks from North Carolina.)

Bangs, O., "The Geographical Distribution of the Eastern Races of the Cottontail (*Lepus sylvaticus* Bach.) With Description of a New Subspecies", Proc. Soc. Nat. Hist., Vol. 26, pp. 404-416. (Mentions specimens from North Carolina.)

Bangs, O., "A Review of the Squirrels of Eastern North America", Proc. Biol. Soc. Wash., Vol. X., pp. 145-167, Dec. 28, 1896. (Contains records of *Sciurus niger*, *S. hudsonius*, and *S. carolinensis* from North Carolina.)

Bangs, O., "The Eastern Races of the American Varying Hare, With Description of a Subspecies from Nova Scotia", Proc. Biol. Soc. Wash., Vol. XII., pp. 77-82, March 24, 1898. (Mentions *Lepus americanus virginianus* as occurring as far south as White Sulphur Springs, West Virginia.)

Bailey, V., "Revision of the American Voles of the Genus Microtus", N. Am. Fauna, No. 17, 1900. (Gives North Carolina records of *M. pinetorum*, *M. p. scalopsoides*, *M. pennsylvanicus*, *M. penn. nigrans.*)

Batchelder, C. F., "Some Unrecognized Mice of the Genus Zapus", Proc. New Eng. Zool. Club, Vol. I., pp. 3-7, February 8, 1899. (Mentions *Z. hudsonius americanus* from Raleigh, North Carolina.)

Brimley, C. S., "List of the Mammals of Raleigh, North Carolina", American Naturalist, May, 1897.

Brimley, C. S., "An Incomplete List of the Mammals of Bertie county, North Carolina", American Naturalist, March, 1897.

Coues, Elliott, "Notes on the Natural History of Fort Macon,

North Carolina", Proc. Acad. Nat. Science, Philadelphia, May 2, 1871, pp. 1-49.

Elliott, D. G., "A List of Mammals Obtained by Thaddeus Surber in North Carolina, South Carolina, Georgia, and Florida", Field Columbian Mus. Publ. 58, June, 1901.

Howell, A. H., "Revision of the Skunks of the Genus Chincha" (Mephitis), N. A. Fauna, No. 20, 1901. (Mentions *Chincha elongata* from North Carolina.)

Merriam, C. Hart, "Remarks on the Fauna of the Great Smoky Mountains, With Description of a New Species of Redbacked Mouse (Evotomys carolinensis)", Am. Journal of Science, Vol. XXXVI., December, 1888, pp. 458-460. (Applies wholly to North Carolina.)

Merriam, C. Hart, "Description of Twenty-Six New Species of North American Mammals", N. A. Fauna, No. 4, 1890. (Mentions *Spilogale ringens* from Cherokee, North Carolina.)

Merriam, C. Hart, "Synopsis of the Weasels of North America", N. A. Fauna, No. 11, 1896. (Mentions *P. noveboracensis* occurring in North Carolina.)

Merriam, C. Hart, "The Occurrence of Cooper's Lemming Mouse in the Atlantic States", Proc. Biol. Soc. Wash., Vol. VII., pp. 175-177, December 22, 1891. (Mentions specimens from Roan Mt., North Carolina.)

Merriam, C. Hart, "Description of a New Subspecies of Chipmunk", Am. Naturalist, Vol. XX., No. 2, February, 1896. (Mentions a specimen from Jackson county, North Carolina.)

Merriam, C. Hart, "Revision of the Shrews of the Genera Blarina and Notiosorex", N. A. Fauna, No. 10, 1895. (Mentions *B. brevicauda*, *B. carolinensis*, and *B. parva* from North Carolina.

Merriam, C. Hart, "Synopsis of the American Shrews of the Genus Sorex", N. A. Fauna, No. 10, 1895. (Mentions *Sorex fumeus*, *S. personatus*, and *S. longirostris* from North Carolina.)

Miller, G. S., J., "The Longtailed Shrews of the Eastern United States," N. A. F., No. 10, 1895. (Mentions *S. fumeus*, *S. personatus*, and *S. longirostris* from North Carolina.)

Miller, G. S., Jr., "Key to the Land Mammals of Northeastern North America," Bull. N. Y. State Museum, 1900. (Mentions a number of mammals from North Carolina.)

Miller, G. S., Jr., "Revision of the North American Bats of the Family Vespertilionidae," N. A. Fauna, No. 13, 1897. (Contains several North Carolina records.)

Preble, E. A., "Revision of the Jumping Mice of the Genus Zapus," N. A. Fauna, No. 15, 1899. (Mentions *Z. hudsonius*, *Z. h. americanus*, and describes as new *Z. insignis roanensis* from North Carolina.)

Rhoads, S. N., and Young, R. T., "Notes on a Collection of Mammals From Northeastern North Carolina," Proc. Acad. Nat. Sci., Philadelphia, 1897, pp. 303-312.

Rhoads, S. N., "The Marsh or Ricefield Mice of the Eastern United States," American Naturalist, Vol. XXXVI., August, 1902. (Mentions *Oryzomys palustris* from Bertie county, North Carolina, which is an error, as the specimens actually came from Raleigh, Wake county.)

Rhoads, S. N., "Contributions to the Zoology of Tennessee, No. 3, Mammals," Proc. Acad. Nat. Sci., Philadelphia, 1896, pp. 175-205. (Contains records of a number of species of mammals from Roan Mt., North Carolina.)

Rhoads, S. N., "Contributions to a Review of the North American Beavers, Otters and Fishers," Trans. Am. Philos. Soc. N. S., XIX., pp. 417-439. (Describes *Castor c. carolinensis* from North Carolina and refers North Carolina Otters to *L. h. lataxina*.)

True, F. W., "A Revision of the American Moles," Proc. U. S. Nat. Mus., Vol. XIX., pp. 1-112, 1896. (Contains North Carolina records of *Parascalops breweri*, *Condylura cristata* and *Scalops aquaticus*.)

THE METHOXYL GROUP IN CERTAIN LIGNOCELLULOSES.

ALVIN S. WHEELER.

Extended study of lignified tissue has led to the belief that it is essentially a chemical compound and the term lignocellulose is applied to it. The molecule is a very complex one and among the characteristic features of it is the constant proportion of methoxyl, OCH_3. Benedikt and Bamberger* first brought this fact into prominence. The proportion of methoxyl, calculated to methyl, is approximately two and one half per cent. I have extended the work, making determinations in woods mostly native to this country. The Tree of Heaven, China Tree and Paulownia originated in Eastern Asia but are now found wild in this country. The Crab Wood and Wild Lime are native to the Bahama Islands and the West Indies and the samples were obtained from Dr. W. C. Coker.

The determinations were made according to the method of Zeisel. In most cases the wood was taken from small stems. It was cut into small chips, after removal of the bark and dried to constant weight in a steam oven. The values obtained correspond to those of Benedikt and Bamberger. The results are as follows:

Persimmon,	Diospyros Virginiana, L.	1.95
Umbrella Tree,	Magnolia tripetala, L.	2.57
Sassafras,	Sassafras Sassafras (L) Kant	2.44
Chinquapin,	Castanea pumila, (L) Mill	2.16
Buttonwood,	Platanus occidentalis, L	2.23
Witch Hazel,	Hamamelis Virginiana, L	2.67
Pig Nut Hickory,	Hicoria glabra, (Mill) Britton	2.32

*Monatsh. of Chem. II., 260-267.

Sweet Gum,	Liquidambar Styraciflua, L.	2.24
Dogwood,	Cornus florida, L.	2.37
Honey Locust,	Gleditsia triacanthos, L.	2.47
Tree of Heaven,	Ailanthus glandulosa, Desf.	2.52
China Tree,	Melia Azederach, L.	2.35
Paulownia,	Paulownia tomentosa, (Thunb)	2.40
Crab Wood,	Gymanthes lucida,	2.95
Wild Lime,	Fagara flava,	2.19

The average is 2.39 per cent. I wish to thank Mr. Preston Irwin for assistance in making the determinations.

Chapel Hill, N. C.

THE SPONGES OF THE "ALBATROSS" 1891 EXPEDITION.

Memoirs of the Museum of Comparative Zoology at Harvard College, Vol. XXX., No. 1. *Reports on an Exploration off the West Coasts of Mexico, Central and South America, and off the Galapagos Islands*, in charge of Alexander Agassiz, by the U. S. Fish Commission Steamer "Albatross," during 1891, Lieut. Commander Z. L. Tanner, U. S. N., commanding. XXX. *The Sponges*, by H. V. Wilson. Cambridge, U. S. A., 1904. Pp. 164, with 26 plates.

The following synopsis of results is abstracted from the introduction to the above report.

The collection of sponges with which the following report deals has been found to include forty-seven species and subspecies. Of these, twenty-six, representing thirteen genera, fall into the Hexactinellida, seven, representing three genera, fall in the Tetractinellida, and fourteen, representing nine genera, fall in the Monaxonida. No calcareous or horny sponges and no Lithistids were taken. As was to have been expected, since the expedition was made in unexplored waters, a very large percentage of the forms (thirty-three species and subspecies) prove new to science.

LIST OF THE SPECIES TAKEN.

Hyalonema ovuliferum F. E. Sch.
" *pedunculatum*, sp. nov.
" *bianchoratum*, sp. nov.
" *pateriferum*, sp. nov.
" sp. div.
Euplectella, sp.
Regadrella, sp.
" *delicata*, sp. nov.

Caulophacus schulzei, sp. nov.
" sp.
Bathydorus levis spinosus, subsp. nov.
Staurocalyptus sp.
Farrea occa claviformis, subsp. nov.
" *mexicana*, sp. nov.
" sp.
Eurete erectum tubuliferum, subsp. nov.
" " *mucronatum*, subsp. nov.
" " *gracile*, subsp. nov.
" sp.
Aphrocallistes vastus F. E. Sch.
Chonelasma calyx F. E. Sch.
Bathyxiphus sp.
Hexactinella labyrinthica, sp. nov.
" *ventilabrum* Carter.
" *tubulosa* E. E. Sch.
Sclerothamnopsis compressa, gen. et, sp. nov.
Thenea fenestrata(O. Schmidt) Sollas.
" *echinata*, sp. nov.
" *lamelliformis*, sp. nov.
" *pyriformis*, sp. nov.
Poecillastra tricornis, sp. nov.
" *cribraria*, sp. nov.
Penares foliaformis, sp. nov.
Polymastia maeandria, sp. nov.
Petrosia variabilis crassa, subsp. nov.
" *similis densissima*, subsp. nov.
Pachychalina acapuclensis, sp. nov.
Oceanapia bacillifera, sp. nov.
Gellius perforatus, sp. nov.
Tylodesma alba., sp. nov.
" *vestibularis*, sp. nov.
Iophon chilifer ostia-magna, subsp, nov.
" *lamella*, sp. nov.
" *lamella indivisus*, subsp. nov.

Iophon indentatus, sp. nov.
Phakellia lamelligera, sp. nov.
Auletta dendrophora, sp. nov.

In addition to the discovery of new forms, some results of general biological interest have accrued from the study of the collection, and are discussed or stated under the respective species concerned. For convenience of reference the more important of these facts may be here classified.

Remarkable forms. *Hyalonema pedunculatum* is noteworthy for the peculiar pedunculate form of body; *Sclerothamnopsis compressa* for the shrub-like habitus in which it resembles the hitherto unique *Sclerothamnus clausii* Marsh.; *Regadrella delicata* for the character of the sieve-plate region, which may be construed as representing a simpler (although not necessarily a more primitive) phylogenetic condition than the otherwise closely similar *Regadrella phoenix* O. Schm.

Distribution and *Habitat.* *Thenea fenestrata* O. Schm., hitherto known only from the Atlantic and Caribbean Sea, is now recorded for the Pacific. Some of the Hexactinellids from great depths have been found to live clustering upon one another: *Caulophacus* attached to root spicules of *Hyalonema*; *Bathydorus* attached to root spicules of *Hyalonema* and to stalks of *Caulophacus* or similar sponge.

Morphology in general. Further evidence of a convincing character has been gained that the *Eurete* and *Farrea* colonies are derived ontogenetically from simple cup-like forms. ——The close similarity between the main afferent and efferent canals and their apertures in *Poecillastra tricornis* is worthy of remark.——The observations of Sollas and of Dendy on the occurrence of a peculiar fenestrated membrane (Sollas's membrane) in the flagellated chambers of certain sponges have been confirmed for two tetractinellid genera, *Poecillastra* and *Penares*.

Pathological phenomena in general. In *Euplectella* skeletal septa of a reticular character have been found crossing the

cavity of the sponge.——In *Chonelasma* similar septa have been observed.——In *Hexactinella labyrinthica* skeletal masses of a reticular character, such as have been especially described by Weltner, occur. In some cases such masses form layers separating one part of the sponge from another.——Possibly all these phenomena are pathological and similar, in so far as they may indicate an effort of the sponge to shut off one one part (diseased?) of the body from the rest.

Morphology of spicules—variations and "*pathological*" *conditions.* In *Hyalonema pateriferum*, pathological amphidiscs such as have been observed by Marshall and Meyer and F. E. Schulze occur. In these spicules several additional rays of the hexact are developed.——Certain details in the structure of the discohexasters of *Caulophacus schulzei* suggest that a hexaster may arise from a hexact through the development of *lateral* branches on the hexact rays.——Another case is afforded by *Hexactinella labyrinthica* of what seems to be the degeneration of an uncinate into an oxydiact.——In scopulae present in *Sclerothamnopsis compressa*, the arrangement of the axial canals indicates that the spicule is equivalent to a branched diact, as Schulze has supposed.——Abundant transitional forms indicate that the protriaenes of *Thenea* are modified *dichotriaenes.*——In *Thenea pyriformis* a type of metaster is common which may be interpreted as transitional between spirasters and euasters.——In *Penares foliaformis* peculiar dichotriaenes are found which approach the shape of the lithistid phyllotriaene.——The occurrence of pathological branching oxeas is recorded for *Petrosia.*

Variation. The variability of sponges in regard to points of adult structure is universally recognized. O. Schmidt and Vosmaer, in particular, have laid stress on the phenomenon as bearing upon the problems of systematic classification. The observations recorded in this report will fall under the following heads:

1. *Variation* in *body-shape* and *general anatomy.*

Attention may be called to the difference in shape exhibited

by specimens of *Hyalonema peteriferum*, *Caulophacus schulzei*, *Thenea fenestrata*, *Petrosia variabilis crassa*.——In *Eurete* the spiral form of body beset with cup-like outgrowths varies towards a bilateral symmetry.——In *Tylodesma alba* massive and lamellate bodies occur, as parts of one continuous specimen.——In *Gellius perforatus* a uniform habit of growth may result in very different body shapes.——In *Thenea* individuals the number and size of pore areas vary; also the spicular fringe round the osculum.——In *Iophon lamella* the character of the surface varies in different parts of the same individual, owing to the divergence in character of the main efferent canals and their apertures, and to the varying amount of collenchyma round such canals.

2. *Variation* in *same individual* in the *skeletal framework*, or the *skeleton in general.*

In *Chonelasma calyx* the tuberculation of the beams of the dictyonal framework varies.——In *Hexactinella ventilabrum* there is considerable variation in the way in which the hexacts combine to form the dictyonal framework.——In *Thenea fenestrata* there is variation in the development of the spicular fringes round the pore areas.——In *Petrosia variabilis crassa* and in *Petrosia similis densissima* a skeletal reticulum remains undeveloped in spots.——In *Pachychalina acapulcensis* the skeletal framework in places is fairly regular, although in general irregular. In *Phakellia lamelligera* the skeletal lamellae vary in respect to branching.——In *Petrosia similis densissima* over some parts of the surface there are no projecting spicules, while over other parts such spicules are present in consideral number.——In *Gellius perforatus* there is considerable variation in the character of the spicular tufts which project from the surface.——In *Iophon lamella* there is variation in the number of spicules which combine to form the side of a skeletal mesh.

3. *Uncorrelated Variation* in the *megascleres* of an *individual*, i. e. variation apparently not correlated with the structural peculiarities of the body-locality.

As regards size of the spicules, there seems to be noticeable variation in all sponge species.——The shape of one of the macramphidiscs varies considerably in *Hyalonema bianchoratum*.——In *Caulophacus schulzei* the principal hexacts are occasionally tuberculated, and in the same species the tuberculation of the pentacts varies.——The character of the diact ends varies commonly, e. g. in *Bathydorus levis spinosus*.——In *Farrea mexicana* the pentacts vary in respect to tuberculation.——In *Eurete erectum* the character of the distal ray of the gastral pinules varies extensively.——In *Petrosia variabilis crassa* the oxea sometimes assumes the shape of a strongyle, or style.——In *Penares foliaformis* the triaenes vary considerably.——In *Pachychalina acapulcensis* the size of the oxea varies within wide limits.——In *Phakellia lamelligera* the oxeas and the two kinds of styles all vary considerably in shape.

4. Uncorrelated variation in the *microscleres* of an *individual.*

The microscleres as well as the megascleres very commonly vary in size and detailed shape, although in them, as in the megascleres, there is a size and pattern which are characteristic of the individual (species), i. e. to which the majority of the spicules of an individual conform.

Some striking cases of variation are afforded by the microoxyhexacts of *Hyalonema bianchoratum*, plesiasters and spirasters of *Thenea fenestrata*, sigmata of *Tylodesma alba.*

5. Correlated variation in the *spicules.*

In some cases the variation of spicules is obviously not ungoverned by the rest of the body, but is correlated with body-locality.

Thus while the pentacts in *Hexactinella labyrinthica* vary at large in respect to length of the several rays, the pentacts overlying the larger inhalent canals commonly have noticeably short proximal rays. Such a phenomenon would customarily be referred to as "adaptive."——The variation of dichotriaenes towards the protriaene type, round the pore areas of

Thenea, is another instance of the same phenomenon.——A complex instance of correlated variation is afforded by the dermal and gastral pinules of *Caulophacus schulzei*, which coat the opposite surfaces (pore and oscular) of the body. The two kinds of pinules vary in the same direction in different individuals, and thus the proportionate difference between them is preserved.

6. *Qualitative variation.*

Two sets of individuals living together in the same locality, and which are otherwise indistinguishable, differ conspicuously in respect to a single point. An instance is afforded by *Eurete erectum mucronatum*, which differs from *Eurete erectum tubuliferum* in having oxyhexasters instead of onychasters. Another instance is afforded by *Iophon lamella indivisus*, which differs from *Iophon lamella* only in the character of the bipocillus, which is not chelate.——In order not to confuse the facts with hypothesis, the two sets of individuals have in each case been separated as subspecies. It is idle to dogmatize or to speculate *in extenso* on the value, from the standpoint of heredity, of the point of difference. Whether this point is inheritable and thus marks off two races, or whether it merely marks off two sets of individuals which started out alike and the offspring of which are alike, and which owe their difference to the action on the individual of the environment, no one can say. The recording of the difference is the duty of the systematist, who, when he has done so, has pointed out an additional case suitable for the experimental study of heredity and environmental action.

7. *Variation towards other species or subspecies.*

A class of spicules in one subspecies may vary in considerable number towards a condition characteristic of a subspecies inhabiting a different locality. An instance is afforded by *Eurete erectum gracile*, in which the tuberculation of the gastral pentacts and hexacts is sometimes very similar to that found in the other subspecies of *Eurete erectum*.

Or a form of spicule characteristic of one species may occur

infrequently in a related species. For instance, in *Caulophacus schulzei* the pinuli occasionally have the shape characteristic of *C. latus* and *C. elegans*. A striking case is afforded by *Farrea occa claviformis*, in which a few gastral clavulae were found closely similar to the peculiar clavulae of *Farrea convolvulus*.

8. Constancy of character in spicules.

It often happens that while in a single individual the *size* of a particular spicule may vary within wide limits, the *character* remains fairly constant—e. g. pinuli of *Hyalonema bianchoratum*.——The character of a spicule even in minute details may apparently become fixed for the species. Thus in a specimen of *Hyalonema ovuliferum* the rays of the microoxyhexacts have the same sudden terminal curving exhibited by the corresponding spicules of Schulze's type specimen, although the two sponges were taken 49° of latitude apart. ——A form of spicule which in some sponges varies greatly in size, in other species varies but little. Thus in *Gellius perforatus* the sigmata vary only slightly, whereas in *Tylodesma alba* they vary greatly.

I do not undertake a comparative consideration of the geographical distribution of the forms making up the collection. Such a consideration would demand a knowledge of the actual systematic value to be attached to many *species* recorded in the literature of sponges. And such a knowledge is not to be had at present. In modern sponge literature, e. g. in the two great monographs of Schulze and Sollas (Schulze, 1887; Sollas 1888), the species conceived are, as it seems to me, what H. M. Bernard contends for in his interesting recent discussions (Proc. Cambridge Phil. Soc. Vol. XI. Pt. IV.; Verhdlg. V. Intern Zool.-Congress) of the species-question as affecting the method of recording certain data, viz. homogeneous morphological groups. The sponge species are often very homogeneous, because represented by single specimens. That such groups answer always to natural species, as we understand the word when we speak of the human race, *Passer domesti-*

cus, *Littorina litorea*, or other organisms which we know in great number, is not only open to doubt, but is excessively improbable. It is, I suppose, from this latter point of view (the envisaging clearly the *a priori* probability that sponges in general exhibit those individual and local differences which all species known intimately exhibit) that O. Schmidt was led to record in literature the existence of such species as *Farrea facunda*. Perhaps *Farrea facunda* is a "natural species," but the data at hand make such a statement only a subjective assumption. Or when the distinguished systematist Topsent expresses the opinion that five species of *Poecillastra* recorded by Sollas probably represent the variations of two or three species, one is justified in saying "perhaps, but the known specimens differ in certain definite respects." Such subjective interpretations of differences perhaps always affect the manner in which we record the occurrence of certain morphological peculiarities in association with geographical and bathymetrical site. But whereas once they were rampant, today they are reduced to a minimum, with the result, as I have said, that the *species* of modern sponge literature are strikingly homogeneous groups, which need not be thought of as always corresponding to natural races.

That this method of precise analysis is the only method capable of yielding trustworthy data, seems to me incontestable. That it may result in temporarily recording more species than exist in nature, will only trouble those who incline to the view that the one excuse for systematic zoölogy is to provide them with a handy collection of names for the animal kingdom.

The data which are thus accumulating as to the occurrence of this or that peculiarity of structure in a certain locality are growing rapidly through the labors of systematists. Scarcely begun is the accumulation of the almost equally important data (comp. Poléjaeff, Report on the "Challenger Keratosa," p. 85), as to what peculiarities of structure are due to a difference in the physiological state of individuals

belonging to the same race. Such knowledge, to be acquired through continuous observation of living individual sponges under normal and under modified conditions (experimental method) may be expected to bring about the union of many recorded *species*.——Another most important class of data can only be revealed through the physiological study of the *race*, viz. through the breeding of sponges. And with the increase in the number of marine laboratories at which observations may be carried on continuously throughout the year, the inauguration of such studies may be anticipated. ——The modern statistical method of considering the differences between individuals of such groups as are procurable in large numbers is a refinement of what is commonly understood as systematic work, and a promising field for those acquainted with the structure of sponges. Such studies, by revealing the kinds and the extent of structural modifications which occur among individuals not separable into morphologically definable groups, may be expected to provide invaluable special cases for experimental study.——It is through the combination of these several classes of data that we must hope to learn the limits of the natural groups of sponges as as they exist today. When such trustworthy definitions of natural groups are at hand, the facts of the geographical distribution of the species will doubtless become intelligible.

THE ATOMIC WEIGHT OF THORIUM.*

BY R. O. E. DAVIS.

The atomic weight of thorium has been determined with varying results. The values are dependent upon the analyses of the oxalates, sulphates, formate, acetate and acetonyl-acetonate. The first value is due to Berzelius[1] and was obtained from the sulphate and double sulphate of thorium and potassium. The thorium was estimated by precipitation with ammonia and the sulphuric acid as BaS04. The value obtained was 234.8.

In 1861 Chydenius[2] published new determinations from analyses of sulphates, acetate, formate and oxalate. The mean of his determinations gave thorium, 233.1. Two years later in 1863 Marc Delafontaine published some researches on thorium[3]. His studies were particularly on the sulphates. The thorium he estimated in two ways: (1) by precipitation as oxalate and subsequent ignition, (2) by direct calcination. From his work a value of 230.3 for thorium was obtained.

The next determinations were those of Cleve[4]. His work was with the sulphates and oxalates. Next came the work of Nilson[5] on the sulphates. Then in 1887 Kruss and Nilson[6] published determinations. Of the most trustworthy values given by Clarke[7] the value for thorium varies from 223.06 to 236.93, a mean giving the value 232.6.

*[Dissertation presented to the faculty of the University of North Carolina for the degree of Doctor of Philosophy.

[1]Poggend Annal., 16, 398. 1829.

[2]Poggend Annal, 199, 55. 1863.

[3]Arch. Sci. Phys. et Nat. (2) 18, 343,

[4]Jour. fur Prakt. Chem., 93, 114.

[5]Ber. Deutsch. Chem. Gesell., 15, 2519. 1882.

[6]Ber. Deutsch. Chem. Gesell. 20, 1665, 1887.

[7]Constants of Nature, Part V.

Due to the great variation in values as given by different authorities and determined by different methods, and also the just criticisms which have been lodged against those methods for other elements, it was deemed advisable to redetermine the atomic weight of thorium. We began by first investigating the methods formerly used and then attempted a new method, with what success the sequel will show. In addition to the criticism to which the various methods are subject, recent investigations by Brauner[1] and Baskerville[2], who have been busied for years with the element, point to the complexity of thorium. Moreover the radio-activity associated with thorium is illy understood and appears not to belong to pure thorium compounds.

Of methods used the value 232.6 depends on those of the oxalate, formate, acetate and acetonyl-acetonate. With oxalate, formate, acetate and acetonyl-acetate we have organic compounds with a large number of atoms in the molecules and varying number of molecules of water of crystallization present. For instance, in the oxalate we have $Th(C_2O_4)_2$, $6H_2O$, and the acetonyl-acetonate $Th(C_5H_7O_2)_4$; molecules with thirty-one and fifty-seven atoms in them respectively. It is at once evident that such complex molecules are not satisfactory for atomic weight determinations.

It is upon the sulphate method chiefly that the atomic weight of thorium depends, but the sulphate determinations are open to serious objections. There is objection to using any hydrated salts, because of the uncertainty of the composition. The anhydrous sulphate is objectional because of its porous and deliquescent nature. Yet there are other difficulties of much more importance than these. In most cases the ratio between thorium oxide and sulphate was established by incinerating the sulphate. This is a difficult process and it is extremely doubtful if all the sulphate can be decomposed, as it forms a protective coating of oxide.

[1]London Ch. Soc. April, 10, 1901.
[2]J. American Ch. Soc., Vol. 23, No. 10., Oct,, 1901.

In some cases the amount of sulphuric acid is determined by precipitation as $BaSO_4$. This is also a very objectionable process, because of the well known property of barium sulphate to occlude foreign substances and hence should be excluded from atomic weight work. While the values obtained from the sulphate method may lie close to the real value of thorium, they probably deviate from it by several points.

From the above considerations it was first decided in this work to make some determinations by the sulphate method in order to test its accuracy. For the material used we are indebted to Dr. H. S. Miner, of the Welsbach Lighting Co., Gloucester, N. J., who generously supplied us with a large quantity of commercial thorium nitrate. This thorium we purified by several of the accepted methods of purification. Half kilo of the nitrate was dissolved in three litres of water and precipitated as hydroxide with ammonia. This was thoroughly washed, then dissolved in HCl. The solution was reprecipitated by ammonia. The other part was neutralized by ammonia until a slight precipitate persisted and the thorium precipitated by the addition of sodium nitrite. The precipitate was thoroughly washed, then dissolved in acid and the precipitation repeated.

One portion we attempted to purify by changing to the chromate, but on subsequent treatment, the chronium was so difficult to remove that this portion was not used in any of our work on the atomic weight of thorium.

Another half kilo, after precipitation by ammonia, was purified by dissolving in ammonium carbonate solution, and then precipitated by ammonia.

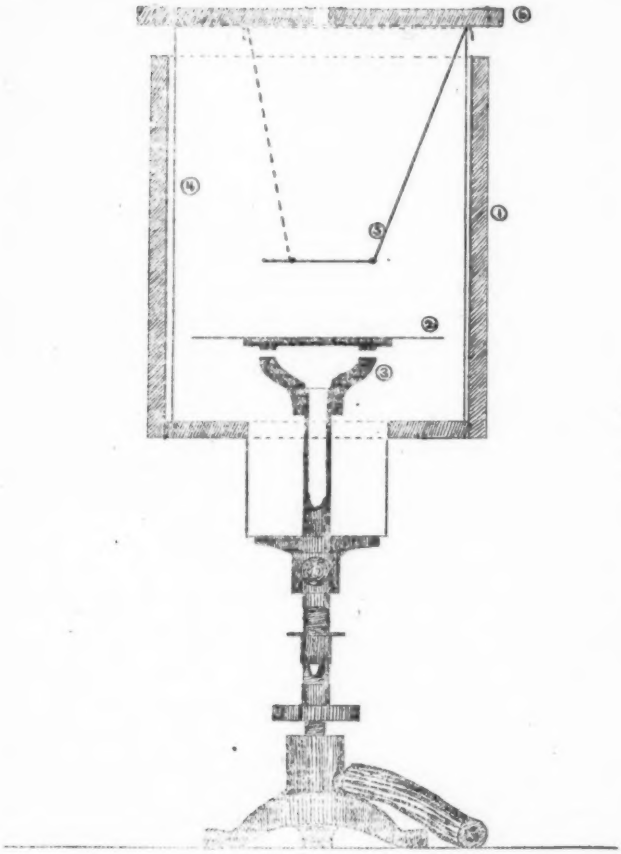
Then a portion of this precipitate was purified by the citrate method. A saturated solution of citric acid was saturated with thorium hydroxide and stirred for twenty-four hours. After the citric acid would take up no more thorium hydroxide, the undissolved hydroxide was filtered off, and the filtrate was heated in a water-bath with boiling water. A heavy white precipitate came down. This was filtered through

a hot funnel with aid of suction and washed until free from acid. From each of these different sources the thorium was used in the work to be described below.

In this work the crucibles were obtained specially for the purpose and were never used for anything else. The crucible in which the substance was weighed was counter-poised by a crucible as near the same size and weight as possible. The weights were specially standardized by the Bureau of Standards and Weights at Washington and were never used for any other work than this. The balances were adjusted to a constant load and every weight made at that load. The balances were not used for any other purpose after the beginning of this work. The weighings were made by the method of vibrations and were made to 0.000001 of a gramme.

After the purity of our thorium compounds was proven by spectroscopic examination, we first turned our attention to the determination of the atomic weight by the synthesis of the sulphate from the oxide. The method of Gerhard Kruss' was used. The oxide was brought to constant weight by heating with a blast lamp, then evaporating with sulphuric acid (1:1) several times to convert all the oxide into sulphate. Then the sulphate was brought to constant weight at a temperature of 360°C. In bringing the sulphate to constant weight, a bath of platinum was used. This bath consisted of a cylindrical tube of copper, about four inches in diameter, mounted above a rose burner, and lined inside with platinum and outside with asbestos. The crucible was suspended in the center of the bath by a ring of platinum wire. The temperature was taken by inserting a mercury thermometer beside the crucible. The mercury was under twenty atmospheres of pressure by carbon dioxide, and the thermometer was graduated to 560°C. It was standardized at the Reichs Anstalt. The results were not strictly concordant and an investigation showed that the ratio between oxide and sulphate varied with the temperature.

[1]Chem. News, Jan. 30, 1893. Pp. 52.



(1) Copper Cylinder, sheathed with Asbestos, resting on three-armed Support, clamped to Bunsen Burner. (2) Platinum Plate, resting on Rose Burner, (3). (4) Platinum Cylinder resting on Asbestos Mat. (5) Platinum Triangle, supported by Platinum Wire Hooks. (6) Asbestos Cover, lined on the inside with Platinum; Hole in center for Thermometer.

Our work seems to indicate that in the formation of the sulphate a mixture is formed. The portion of the sulphate next to the crucible may have been decomposed while the inner portion would still be acid sulphate. Since the atomic weight determinations carried out by other investigators were not made at a definite temperature, then from our investigations the values might have a wide range. Of course, if a series were carried out under exactly the same conditions, concordant results would be obtained. But still there would remain the question whether all the body was normal sulphate or acid or part acid and part basic.

The determination of the equivalent from the acetonyl-acetonate next claimed our attention. The crystals of acetonyl-acetonate were made, but they showed two forms of crystals so that they were not used. The obvious disadvantage of using such a compound has already been mentioned.

After considering the various methods upon which the equivalent of thorium is dependent we decided to try a new method. Of the compounds of thorium considered the tetrachloride seemed to offer the greatest advantages. By its use the ratio could be determined between the oxide and the chloride, and the values of only three elements would be involved.

The thorium oxide was ground up in an agate mortar with carbon (about one-tenth the weight of the oxide) and the mixture placed in a carbon boat. The boat was placed in a hard glass tube passing through a combustion furnace and while heated to a good red heat, dry chlorine passed through the tube. Beautiful crystals of the chloride formed on the walls of the tube just beyond and above the boat. Still farther, lighter and feathery crystals formed in the tube, and a white vapor, Berzelius's "Weisserdampf", was driven off and caught in alcohol.

The carbon used was obtained by heating crystallized rock candy. The boats were previously heated in a stream of dry chlorine for several hours. The chlorine used was taken from

an iron cylinder, and was analyzed for oxygen and other impurities. About two per cent. of an inert gas was found, but it was not deemed necessary to remove it. The chlorine was dried by passing over a train of eight towers and wash bottles containing sulphuric, and two towers with glass beads and sulphuric acid, then finally through five towers with glass beads and sulphuric acid, this being the apparatus used by Richards[1] in his work on the atomic weight of cobalt and nickel.

The method of determining the ratio between the chloride and the oxide was to weigh the chloride, dissolve in water and evaporate in a platinum crucible, then ignite to constant weight. The portion of the tube in which the crystals were formed was cut out and slipped quickly into a weighing bottle and then placed in an air bath at 160°C. to drive off the chlorine. It was then removed and placed in a dessicator and after an hour weighed. After weighing the chloride was dissolved in water and then the tube returned to the weighing bottle and brought to constant weight. This gave the weight of the thorium tetrachloride.

The solution of thorium tetrachloride was evaporated in a platinum crucible on the water bath, then ignited to constant weight. In order to bring to constant weight the oxide had to be blasted about seventy hours. This gave the weight of the oxide derived from a given amount of the chloride. But no constant relation could be obtained.

Thinking that perhaps the difficulty lay in not being able to drive off all the chlorine by heat and ignition, we turned our attention to the determination of the halogen. A long series of experiments investigating a new method for the determination of the halogen was begun. Since silver chloride is soluble in water to a certain extent, we decided to investigate its solubility in alcohol.

The alcohol used was absolute and freed from aldehyde by fractional distillation until it would not respond to the fus-

[1]Proc. Amer. Acad. Arts & Sci. Vol. 34, No. 13, Pp. 332, 1889.

chine test, which shows one part in a million. Silver nitrate solution was made by dissolving pure silver prepared according to the method of Stas by Venable, in pure nitric acid. A solution of $\frac{N}{10}$ NaCl was made for determining the chlorine. Several series of experiments were carried out to determine the effect of an excess of silver nitrate in solution, of acidity, and of temperature. The temperature was varied from boiling to room temperature (about 23°C.).

One cubic centimeter should have precipitated 0.0143 gm. of AgCl. The following are some of the results.

10. AgCl found, 0.756, theoretical, 0.1716; Temp. 30; excess of $AgNO_3$ 0.1028; acidity, 18.5 cc. $\frac{N}{2}$ acid.

12. AgCl found 0.1732, Temp. 30; excess $AgNO_3$ 0.2399; acidity, 20.4cc. $\frac{N}{2}$ acid.

14. AgCl found 0.1800, Temp. 78; excess $AgNO_3$ 0.2183; acidity 25.6cc. $\frac{N}{2}$ acid.

18. AgCl found 0.1754, Temp. 60; excess $AgNO_3$ 0.0171; acidity 25.6cc. $\frac{N}{2}$ acid.

There were twenty-five determinations carried out, all giving too high results, as may be seen from the figures given. By another series of experiments carried out at thirty degrees with rapid filtration, it was found that the results in general agreed with the theoretical. But the conditions were very hard to attain.

We now returned to our thorium and made a series of experiments to determine the chlorine of the tetrachloride. But the results were not concordant, which fact was explained by finding that even aldehyde-free alcohol decomposes silver nitrate, causing finely divided silver to deposit. Of course this method was immediately abandoned.

Now once again we turned our attention to determining the

ratio between the chloride and the oxide of thorium by direct evaporation of the chloride solution and the subsequent ignition of the residue to the oxide. But noting that the hard glass tube, in which the chloride was formed, seemed to be attacked by the chlorine at the temperature required for the formation of the chloride, it seemed possible that the disagreement of our values might be due to the formation of other chlorides from the glass. A series of experiments confirmed this view that the glass was causing a contamination of our thorium compound. Hence we set about to eliminate this trouble.

Quartz tubes were imported especially for the work. These were about 2 cm. in diameter and 25 cm. long. In one end of one of these was placed the carbon boat with the mixture of carbon and thorium oxide, and the whole inserted in a porcelain tube and placed in the furnace. The porcelain tube was heated while a stream of dry chlorine was passed through. The "Weisser-dampf" settled on the walls of the porcelain tube, near the end, and the crystals of tetrachloride formed in the quartz tube.

For weighing the chloride, special weighing bottles, 39 cm. long, were obtained. Into one of these the quartz tube was quickly inserted on withdrawing it from the porcelain tube, and after removing the carbon boat. A second weighing bottle was used as counter-poise. The solution of the chloride was evaporated and the final ignition to constant weight was the same as when the glass tubes were used. The water used for the solution of the chloride was purified by redistillation in a platinum still.

The quartz tubes also showed signs of attack by the chlorine at the high temperature used, and so the oxide, after becoming constant in weight, was treated with hydrofluoric acid and the loss in weight, usually very small, applied as a correction to the weights of both the chloride and oxide.

Using every precaution in the work we still failed of constant values, most of them falling between 221 and 230; yet

some came lower and some higher than those values. The crystals that seemed to be purest gave values within the limits named. From the inability to obtain a constant value, it seemed that the crystals of chloride must be contaminated. It will be remembered that the crystals of chloride were the middle portion in the formation of the chloride: that is, a light "Weisser-dampf" passed to and condensed on the front of the tube, just beyond the boat were the crystals of the chloride used for the work, and there still remained a residue, mixed with the carbon in the boat, that could not be volatilized. In other words, by distilling thorium oxide in chlorine, three fractions were obtained.

After the first distillation was performed, a determination of the equivalent of each of the end products was made by the sulphate method. The following results were obtained:

Oxide from non-volatile part.	sulphate.	At.Wt.
1.636725 gm.	2.595223	241.44.
Oxide from most volatile.		
0.794692	1.309245	212.70.

As the complexity of thorium had been indicated by Baskerville and the name "Carolinium" proposed for the heavier element, we have applied the name of Carolinium to the heaviest portion. For the lightest the name "Berzelium" was used, and Thorium for the middle portion.

After the redistillation of our carolinium, thorium and berzelium fractions three times, a determination of the atomic weight of each was made by the sulphate method. In changing the oxide into sulphate, sulphuric acid (1:1) was used. This was then carefully evaporated. The berzelium seemed to be rapidly changed; but the thorium and carolinium were more persistent, requiring about four evaporations. In every case sulphuric acid was added and evaporated at least four times, to be sure that all the oxide was converted into sulphate. The carolinium sulphate was perfectly soluble in

water, thus showing that all the oxide had been converted into sulphate.

Two determinations of each, carolinium, thorium and berzelium were run at the same time and subjected to the same conditions as nearly as possible. The sulphate of each was heated at 350°C. to constant weight. The platinum bath already described was used and also some large porcelain crucibles with a platinum ring suspended in the center to hold the crucibles. The crucible with the sulphate was placed on this ring, the large crucible covered with a punctured clock glass, and a thermometer suspended through the hole in the glass just above the sulphate inside the small crucible containing it. The results obtained are given below.

The oxides of the three fractions were different in appearance. The carolinium invariably was gray with pink tinge, the thorium slightly greenish, and the berzelium a little more pronounced green. The sulphates of all are pure white when cold, but that of the thorium is yellow while hot.

The following are the results from the determinations:

(1) Carolinium.

Oxide.	Sulphate.	At. Wt.
1.559290	2.434914	255.5
0.524254	0.819365	255.9
0.549331	0.854810	255.6

(2) Thorium.

Oxide.	Sulphate.	At. Wt.
0.425456	0.694936	220.62.
0·740052	1.210405	220.1

(3) Berzelium.

Oxide.	Sulphate.	At. Wt.
0.306778	0.507505	213.6
0.320618	0.530890	212.0

From this it seemed that we were accomplishing the sepa-

ration of the thorium into three fractions of different atomic weights. The atomic weight of genuine thorium is therefore not yet established.

I wish to express my sincere thanks to Professor Chas. Baskerville not only for his sympathy and assistance in the work, but for the privilege of taking part in an investigation, which has been so fruitful in its results.

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